Amendments in the claims:

1. (currently amended) A sensor for measuring angular velocity in a sensor ~~sensing~~ plane, the sensor comprising:

a) a sensing subassembly comprising:

i) a substantially planar frame parallel to said plane; ~~and~~

ii) a first mass disposed in said plane;

iii) a second mass disposed in said plane laterally to said first mass; and

~~ii)~~ iv) a linkage within said frame and connected to ~~and within~~ said frame, wherein said linkage is connected to ~~and comprising a~~ said first mass and ~~a~~ to said second mass ~~laterally disposed in said plane~~ and wherein said linkage constrains said first and second masses ~~constrained~~ to move in opposite directions perpendicular to said plane;

b) an actuator for driving a first portion of said subassembly into oscillation at a drive frequency; and

c) a transducer for sensing motion of a second portion of said subassembly responsive to said angular velocity.

2. (original) The sensor of claim 1, wherein said actuator is selected from the group consisting of electrostatic actuators, electromagnetic actuators, piezoelectric actuators, and thermal actuators.

3. (original) The sensor of claim 1, wherein said transducer is selected from the group consisting of capacitive sensors, electromagnetic sensors, piezoelectric sensors, and piezoresistive sensors.

4. (original) The sensor of claim 1, wherein said first portion of said subassembly is said linkage and said second portion of said subassembly is said frame.

5. (original) The sensor of claim 4, wherein said actuator comprises an electrostatic actuator connected to said linkage, and wherein said transducer comprises a capacitive sensor connected to said frame.

6. (original) The sensor of claim 1, wherein said first portion of said subassembly is said frame and said second portion of said subassembly is said linkage.

7. (original) The sensor of claim 6, wherein said actuator comprises an electrostatic actuator connected to said frame, and wherein said transducer comprises a capacitive sensor connected to said linkage.

8. (original) The sensor of claim 1, wherein motion of said frame is substantially constrained to rotation about an axis perpendicular to said sensor plane.

9. (original) The sensor of claim 8, wherein said frame is substantially circular.

10. (original) The sensor of claim 1, wherein said frame is substantially rectangular.

11. (original) The sensor of claim 1, wherein said first and second masses are constrained to move only substantially perpendicular to said sensor plane, relative to said frame.

12. (original) The sensor of claim 1, further comprising a hole in at least one of said masses to reduce air resistance.

13. (currently amended) The sensor of claim 1, wherein said linkage further comprises:

a center plate connected to said frame and connected to and in between said first and second masses, wherein said center plate is rotatable about a center axis of rotation;

a first edge plate connected to said frame and to said first mass, wherein said first edge plate is rotatable about a first axis of rotation; and

a second edge plate connected to said frame and to said second mass, wherein said second edge plate is rotatable about a second axis of rotation;

wherein said center, first and second axes of rotation are parallel to each other and ~~plates are rotatable about parallel axes of rotation which~~ are also parallel to said sensor plane.

14. (original) The sensor of claim 13, wherein said center plate further comprises a first lever arm connected to said first mass and a second lever arm connected to said second mass, whereby motion of said masses perpendicular to said sensor plane responsive to rotation of said center plate is increased.

15. (original) The sensor of claim 13, wherein said first edge plate further comprises a lever arm connected to said first mass, whereby motion of said first mass perpendicular to said sensor plane responsive to rotation of said first edge plate is increased.

16. (original) The sensor of claim 13, wherein said second edge plate further comprises a lever arm connected to said second mass, whereby motion of said second mass perpendicular to said sensor plane responsive to rotation of said second edge plate is increased.

17. (original) The sensor of claim 1, wherein said frame has a fundamental frame resonant mode having angular rotation of said frame about an axis perpendicular to said sensor plane.

18. (original) The sensor of claim 1, wherein said linkage has a fundamental linkage resonant mode having oscillation of said first and second masses, substantially 180 degrees out of phase

with respect to each other, in a direction perpendicular to said sensor plane.

19. (original) The sensor of claim 18, wherein said frame has a fundamental frame resonant mode having angular rotation of said frame about an axis perpendicular to said sensor plane.

20. (original) The sensor of claim 19, wherein said frame resonant mode has a higher frequency than a frequency of said linkage resonant mode.

21. (original) The sensor of claim 18, wherein a frequency of said linkage resonant mode is about equal to said drive frequency.

22. (original) The sensor of claim 1, further comprising a substantially planar base parallel to and positioned around said frame.

23. (original) The sensor of claim 22, further comprising a plurality of flexures connecting said base to said frame such that said frame is rotatable about an axis perpendicular to said sensor plane.

24. (original) The sensor of claim 23, further comprising a tab extending from said base which is engaged in a groove within said frame, the combination of said tab and said groove

restricting the range of motion of said frame, thereby protecting said flexures.

25. (original) The sensor of claim 22, further comprising a Silicon reference wafer having a top surface attached to said base, wherein said sensing subassembly and said base are etched from a single Silicon gyroscope wafer.

26. (original) The sensor of claim 25 wherein said reference wafer comprises two recesses to accommodate motion of said first and second masses perpendicular to said sensor plane.

27. (original) The sensor of claim 25, wherein said reference wafer comprises CMOS electronics electrically connected to said sensing subassembly.

28. (original) The sensor of claim 25, further comprising a capacitive sensor for sensing motion of said linkage relative to said reference wafer.

29. (currently amended) The sensor of claim 28, wherein said linkage further comprises:

a center plate connected to said frame and connected to and in between said first and second masses, wherein said center plate is rotatable about a center axis of rotation;

a first edge plate connected to said frame and to said first mass, wherein said first edge plate is rotatable about a first axis of rotation; and

a second edge plate connected to said frame and to said second mass, wherein said second edge plate is rotatable about a second axis of rotation;

wherein said center, first and second axes of rotation are parallel to each other and ~~plates are rotatable about parallel axes of rotation which~~ are also parallel to said sensor plane.

30. (original) The sensor of claim 29, wherein said actuator comprises:

a first edge split electrode positioned beneath said first edge plate on said top surface of said reference wafer and separated from said first edge plate by a predetermined distance d;

a second edge split electrode positioned beneath said second edge plate on said top surface of said reference wafer and separated from said second edge plate by the distance d;

a center split electrode positioned beneath said center plate on said top surface of said reference wafer and separated from said center plate by the distance d.

31. (currently amended) The sensor of claim 30, wherein said first edge electrode, said second edge electrode and said center split electrode ~~electrodes~~ are electrically driven in a cooperative manner to excite an oscillation mode of said linkage

having oscillation of said first and second masses, substantially 180 degrees out of phase with respect to each other, in a direction perpendicular to said sensor plane.

32. (original) The sensor of claim 31, wherein said drive frequency is substantially equal to a resonant frequency of said oscillation mode.

33. (currently amended) The sensor of claim 30, wherein said transducer comprises a capacitive sensor connected to said base and to said frame, and wherein said reference wafer comprises CMOS electronics connected to said capacitive sensor and <u>connected</u> to said <u>first edge electrode, said second edge electrode and said center split electrode</u> ~~electrodes~~, whereby wafer scale integration of said actuator and said transducer is obtained.

34. (original) The sensor of claim 25 further comprising a plurality of flexures connecting said frame to said reference wafer such that said frame is rotatable about an axis perpendicular to said sensor plane, said flexures passing through said base and separated from said base by a plurality of base isolation trenches, whereby stress in said base is not coupled to said flexures.

35. (original) The sensor of claim 34, further comprising a plurality of reference isolation trenches separating said top surface of said reference wafer from said flexures, whereby

surface stress in said top surface of said reference wafer is substantially not coupled to said flexures.

36. (original) The sensor of claim 25, further comprising a Silicon cap wafer having a bottom surface attached to said base.

37. (original) The sensor of claim 36, wherein said cap wafer comprises a recess to accommodate motion of said first and second masses perpendicular to said sensor plane.

38. (original) The sensor of claim 36, wherein said cap wafer is hermetically attached to said base, and said reference wafer is hermetically attached to said base.

39. (original) The sensor of claim 38, wherein a gas pressure within a hermetic enclosure formed by said base, said cap wafer and said reference wafer is substantially different from atmospheric pressure.

40. (original) The sensor of claim 38, wherein said cap wafer is hermetically attached to said base with a Si to SiO_2 fusion bond, and said reference wafer is hermetically attached to said base with a metal seal.

41. (original) The sensor of claim 36, further comprising a plurality of flexures connecting said frame to said cap wafer such that said frame is rotatable about an axis perpendicular to

said sensor plane, said flexures passing through said base and separated from said base by a plurality of base isolation trenches, whereby stress in said base is not coupled to said flexures.

42. (original) The sensor of claim 41, further comprising a plurality of cap isolation trenches separating said bottom surface of said cap wafer from said flexures, whereby surface stress in said bottom surface of said cap wafer is substantially not coupled to said flexures.

43. (original) The sensor of claim 42, wherein said flexures are connected to said reference wafer.

44. (original) The sensor of claim 43, further comprising a plurality of reference isolation trenches separating said top surface of said reference wafer from said flexures, whereby surface stress in said top surface of said reference wafer is substantially not coupled to said flexures.

45. (currently amended) A dual-axis sensor for measuring X and Y components of angular velocity in an X-Y <u>sensor</u> ~~sensing~~ plane, the dual-axis sensor comprising:

A) a first subsensor for measuring the X component of angular velocity, the first subsensor comprising:

a) a first sensing subassembly comprising:

i) a substantially planar first frame parallel to said plane; ~~and~~

ii) a first mass disposed in said plane;

iii) a second mass disposed in said plane laterally to said first mass; and

~~ii)~~ iv) a first linkage within said frame and connected to said frame, wherein said linkage is connected to ~~and comprising a~~ said first mass and ~~a~~ to said second mass ~~laterally disposed in said plane~~ and wherein said first linkage constrains said first and second masses ~~constrained~~ to move in opposite directions perpendicular to said plane;

b) a first actuator for driving a first portion of said first subassembly into oscillation at a drive frequency; and

c) a first transducer for sensing motion of a second portion of said first subassembly responsive to the X component of angular velocity; and

B) a second subsensor for measuring the Y component of angular velocity, the second subsensor comprising:

a) a second sensing subassembly comprising:

i) a substantially planar second frame parallel to said plane; ~~and~~

ii) a third mass disposed in said plane;

iii) a fourth mass disposed in said plane laterally to said third mass; and

~~ii)~~ iv) a second linkage within said second frame and connected to said second frame, wherein said linkage

is connected to ~~and comprising a~~ said third mass and ~~a~~ to said fourth mass ~~laterally disposed in said plane~~ and wherein said second linkage constrains said third and fourth masses ~~constrained~~ to move in opposite directions perpendicular to said plane;

b) a second actuator for driving a first portion of said second subassembly into oscillation at a drive frequency; and

c) a second transducer for sensing motion of a second portion of said second subassembly responsive to the Y component of angular velocity.

46. (currently amended) A sensor for measuring angular velocity in a sensor ~~sensing~~ plane, the sensor comprising:

a) a first sensing subassembly comprising:

i) a substantially planar first frame parallel to said plane; ~~and~~

ii) a first mass disposed in said plane;

iii) a second mass disposed in said plane laterally to said first mass; and

~~ii)~~ iv) a first linkage within said frame and connected to said frame, wherein said linkage is connected to ~~and comprising a~~ said first mass and ~~a~~ to said second mass ~~laterally disposed in said plane~~ and wherein said first linkage constrains said first and second masses ~~constrained~~ to move in opposite directions perpendicular to said plane;

b) a first actuator for driving a first portion of said first subassembly into oscillation at a drive frequency;

c) a first transducer for sensing a first motion of a second portion of said first subassembly responsive to said angular velocity;

d) a second sensing subassembly comprising:

i) a substantially planar second frame parallel to said plane; ~~and~~

ii) a third mass disposed in said plane;

iii) a fourth mass disposed in said plane laterally to said third mass; and

~~ii)~~ iv) a second linkage within said second frame and connected to said second frame, wherein said linkage is connected to ~~and comprising a~~ said third mass and ~~a~~ to said fourth mass ~~laterally disposed in said plane~~ and wherein said second linkage constrains said third and fourth masses ~~constrained~~ to move in opposite directions perpendicular to said plane, wherein said second linkage has substantially the same configuration and orientation as said first linkage, said third mass corresponding to said first mass and said fourth mass corresponding to said second mass;

e) a second actuator for driving a first portion of said second subassembly into oscillation at a drive frequency; and

f) a second transducer for sensing a second motion of a second portion of said second subassembly responsive to said angular velocity;

wherein signals from said first and second transducers are combined to distinguish said ~~motion~~ first and second motions responsive to said angular velocity from a motion not responsive to said angular velocity.

47. (original) The sensor of claim 46, wherein said first portion of said first subassembly is said first linkage, and wherein said second portion of said first subassembly is said first frame, and wherein said first portion of said second subassembly is said second linkage, and wherein said second portion of said second subassembly is said second frame.

48. (original) The sensor of claim 47, wherein said first and second linkages are driven such that said first mass and said third mass are driven to move in opposite directions perpendicular to said plane.

49. (currently amended) The sensor of claim 48, wherein said first and second frames are rotatable within said plane, and further comprising a frame linkage connecting said first frame to said second frame, wherein ~~whereby~~ said first and second frames are constrained to rotate in opposite directions by said frame linkage.

Comments on amendments to the claims

The claims are currently amended to overcome claim rejections made under 35 USC 112. No new matter is introduced.

Office action paragraph 2: Claim rejections under 35 USC 112

Claims 1-49 stand rejected under 35 USC 112 second paragraph for the following informalities:

Claim 1, unclear what is connected to the linkage;

Claims 8, 11, 13-19, 23, 26, 29, 31, 34, 37, and 41 recite "said sensor plane" without antecedent basis;

Claim 13 and 29, "said plates" is vague;

Claims 31 and 33, "said electrodes" is vague;

Claim 45, "second" should be inserted before "frame" in line 24;

Claim 46, "said motion" on line 34 is vague.

Claim 1 is currently amended to recite that the linkage is connected to the frame and is also connected to the first and second masses, thereby clarifying what is connected to the linkage. Corresponding amendments are also made to independent claims 45 and 46.

Claim 1 is currently amended to recite "sensor plane" instead of "sensing plane", thereby providing antecedent basis for "sensor plane" in claims 8, 11, 13-19, 23, 26, 29, 31, 34, 37, and 41.

Claims 13 and 29 are amended to clarify "said plates".

Claims 31 and 33 are amended to clarify "said electrodes".

Claim 45 is amended to incorporate the indicated correction.

Claim 46 is amended to clarify "said motion".

Office action paragraph 4: Claim rejections under 35 USC 102

Claims 1-12, 17-28 and 34-44 stand rejected under 35 USC 102(b) as anticipated by US 6,189,381, hereinafter Huang.

It is well known in the angular rate sensor art that the Coriolis force, proof mass velocity and angular velocity to be sensed are three mutually perpendicular vectors. It is convenient to refer to the proof mass velocity vector as the "drive" vector, since this velocity is typically driven by a transducer coupled to the proof mass. Similarly, it is convenient to refer to the Coriolis force vector as the "sense" vector, since motion induced by a Coriolis force in the sense direction is typically sensed in order to measure angular velocity. Thus drive, sense and angular velocity vectors are mutually perpendicular.

With respect to claim 1, Applicant respectfully traverses this rejection, on the grounds that Huang does not teach or suggest the claimed invention. More particularly, Huang relates to an angular rate sensor having two masses in a frame in a sensor plane (taken to be the X-Y plane). The masses are driven into oscillation along the X direction, and experience a Coriolis force in the Y direction to sense Z directed angular velocity. The X and Y directions can be exchanged in the

preceding description. Thus the sensor of Huang is a Z axis (or out of plane) angular rate sensor, since the drive and the sense are both in-plane. In sharp contrast, the claimed invention is an in-plane angular rate sensor that is responsive to angular rotation about the X (or Y) axis. This fundamental difference between the present invention and the sensor of Huang leads to clear differences between Huang and the limitations of claim 1.

More specifically, claim 1 recites "A sensor for measuring angular velocity **in** a sensor plane" (emphasis added). Thus if the sensor plane is taken to be the X-Y plane, the angular velocity sensed by the sensor of claim 1 is **in** the X-Y plane. The sensor of Huang is a Z-axis sensor. Thus claim 1 does not read on the sensor of Huang. In coordinate-independent terms, the frame and masses of Huang lie within a single plane, (i.e., the sensor plane), and the drive and sense of Huang also lie within the sensor plane. Thus the sensor of Huang is incapable of measuring an angular velocity **in** the sensor plane. Thus claim 1 does not read on Huang no matter how the coordinate axes are aligned to the physical structures.

Claim 1 also recites "wherein said linkage constrains said first and second masses to move in opposite directions **perpendicular to said plane"** (emphasis added). The masses of Huang move within the sensor plane (X-Y plane of Huang). Thus these masses do not move perpendicular to the sensor plane and the linkage of Huang does not constrain the masses to move in opposite directions perpendicular to the sensor plane. Accordingly, Huang does not teach or suggest "wherein said linkage constrains said first and second masses to move in opposite directions **perpendicular to said plane"** because the

masses of Huang are constrained to move in the sensor plane (i.e., in the X-Y plane). The fundamental reason for this structural difference between Huang and the claimed invention is that Huang is an out-of-plane (or Z axis) sensor, while the claimed invention is an in-plane (or X-Y axis) sensor.

Furthermore, it would not be obvious to modify the sensor of Huang to arrive at the invention of claim 1, since such modification would fundamentally alter the operating principles of Huang. More specifically, the planar technology of Huang provides very different fabrication capabilities for in-plane (i.e., X or Y) structures (and motions) as compared to out-of-plane (i.e. Z) structures (and motions). Accordingly, there would be no reasonable expectation of success in modifying a structure having in-plane drive and sense (e.g., Huang) to a structure having drive or sense out of the sensor plane (e.g., the claimed invention). Furthermore, a stated intention of Huang is to "suppress out-of-plane displacement" (lines 32-33 of column 3), so Huang also teaches away from any such modification.

For these reasons, Applicant respectfully requests withdrawal of this rejection of claim 1.

Claims 2-12, 17-28 and 34-44 depend from claim 1, so the above arguments and amendments in connection with claim 1 are also responsive to this rejection of claims 2-12, 17-28 and 34-44. Further comments follow with respect to some of these dependent claims.

The further limitation of claim 11 to "wherein said first and second masses are constrained to move only substantially

perpendicular to said sensor plane, relative to said frame" is not taught or suggested by Huang. As indicated above, Huang does not consider out of plane motion of the proof masses.

The further limitation of claim 18 to "wherein said linkage has a fundamental linkage resonant mode having oscillation of said first and second masses, substantially 180 degrees out of phase with respect to each other, in a direction perpendicular to said sensor plane" is not taught or suggested by Huang. As indicated above, Huang does not consider out of plane motion of the proof masses.

The further limitation of claim 20 to "wherein said frame resonant mode has a higher frequency than a frequency of said linkage resonant mode" is not taught or suggested by Huang. Huang has no teaching relating to resonant mode frequencies.

The further limitation of claim 21 to "wherein a frequency of said linkage resonant mode is about equal to said drive frequency" is not taught or suggested by Huang. Huang has no teaching relating to resonant mode frequencies.

The further limitation of claim 24 to "a tab extending from said base which is engaged in a groove within said frame, the combination of said tab and said groove restricting the range of motion of said frame, thereby protecting said flexures" is not taught or suggested by Huang. Huang does not teach a combination of tab and groove as in claim 24.

The further limitation of claim 34 to "a plurality of flexures connecting said frame to said reference wafer such that said frame is rotatable about an axis perpendicular to said sensor plane, said flexures passing through said base and **separated from said base** by a plurality of base isolation

trenches, whereby stress in said base is not coupled to said flexures" is not taught or suggested by Huang. The flexures of Huang (e.g., 7 on Fig. 3H and Fig. 2) are connected to wafer 52 and to wafer 51. In sharp contrast, the further limitation of claim 34 requires mechanical separation of the flexure from the base (i.e., from the rest of wafer 52 of Huang), such that the flexure is anchored directly to the reference wafer (i.e., wafer 51 of Huang), as shown on Figs. 3 and 4 of the present application.

The further limitation of claim 38 to "wherein said cap wafer is hermetically attached to said base, and said reference wafer is hermetically attached to said base" is not taught or suggested by Huang. Huang does not contemplate hermetic attachment.

The further limitation of claim 40 to "wherein said cap wafer is hermetically attached to said base with a Si to SiO_2 fusion bond, and said reference wafer is hermetically attached to said base with a metal seal" is not taught or suggested by Huang. Huang does not contemplate hermetic attachment and does not contemplate a metal seal for bonding.

The further limitation of claim 41 to "a plurality of flexures connecting said frame to said cap wafer such that said frame is rotatable about an axis perpendicular to said sensor plane, said flexures passing through said base and **separated from said base** by a plurality of base isolation trenches, whereby stress in said base is not coupled to said flexures" is not taught or suggested by Huang. The flexures of Huang (e.g., 7 on Fig. 3H and Fig. 2) are connected to wafer 52 and to wafer 53. In sharp contrast, the further limitation of claim 41

requires mechanical separation of the flexure from the base (i.e., from the rest of wafer 52 of Huang), such that the flexure is anchored directly to the cap wafer (i.e., wafer 53 of Huang), as shown on Figs. 3 and 4 of the present application.

Office action paragraph 6: Claim rejections under 35 USC 103

Claims 45-49 stand rejected under 35 USC 103(a) over Huang.

Independent claims 45-46 have substantially the same limitations as claim 1. Accordingly, Applicant respectfully traverses this rejection of claims 45-46 for the reasons given above in connection with claim 1.

Claims 47-49 depend from claim 46. Accordingly, the above arguments in connection with claim 46 are also responsive to this rejection of claims 47-49.

Furthermore, the limitation of claim 49 to "wherein said first and second frames are constrained to rotate in opposite directions by said frame linkage" is not mere duplication, as asserted in the Office Action. Instead, the configuration of claim 49 allows further rejection of common-mode motion as discussed in connection with Figs. 14a-b on pages 27-29 of the specification.

Office action paragraph 7: Allowable subject matter

Claims 13-16 and 29-33 stand as allowable if rewritten in independent form.

Applicant appreciates the indication of allowable subject matter.